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ABSTRACT

A project was conducted in Australia to identify the training needs of the emerging industry required to support the development of the high performance areas of the automotive machining and reconditioning field especially as it pertained to auto racing. Data were gathered through a literature search, interviews with experts in the field, and questionnaires mailed to the managers of a range of automotive reconditioning businesses in each Australian state and territory. The study found that there are not enough skilled people to provide the services demanded by racing teams. Skills most needed included welding and electronics. The project clearly identified a need for a post-apprenticeship course that will provide an advanced level of technological skills for the machining, building, and operation of high performance engine and mechanical components. The course should include instruction in the areas of machining, engine design, engine assembly, engine testing, and welding and fabrication. Appropriate apprenticeships also were recommended for areas of the country in which they are not available. (KC)

TRAINING NEEDS FOR HIGH PERFORMANCE IN THE AUTOMOTIVE INDUSTRY

Barry Clyne
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Roger Calvert

RICHMOND COLLEGE OF TAFE - 1989

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FOREWORD

This report was funded by a "seed grant" from the TAFE National Centre for Research and Development at Payneham, South Australia. The availability of this type of funding for research is very much appreciated.

The aim of this project is:

> To identify the training needs of the emerging industry required to support the development of the high performance areas of the automotive machining and reconditioning field with particular attention to the use of materials and the development of mechanical components to produce maximum efficiency.

The writers would like to extend their thanks to the many people who actively assisted in the preparation of this report. To the members of CAMS who provided a valuable insight into motor racing and to the many people throughout the industry who took part in the study and provided valuable advice and information. The input from Engine reconditioning managers throughout Australia also deserves particular recognition. Their interest in training needs related to the area of engine reconditioning was very obvious and indicates a healthy future for the trade.

RECOMMENDATIONS

Based on the conclusions and findings of this study, the following recommendations were reached.

1. To provide a post-apprenticeship course of advanced skills for the machining, building and operation of high performance engines and mechanical components in the following areas:

    a) Precision machining of components
    b) Engine design considerations
    c) Engine assembly and blue-printing
    d) Engine testing and evaluation
    e) Welding and fabrication

2. The design of the above course should address the varying needs of Engine Reconditioners throughout Australia and also encourage participation by utilizing a flexible approach such as Open Learning.

3. To determine the means by which the need for initial training in Engine Reconditioning can be provided in those localities which currently are not effectively serviced by appropriate apprenticeships.

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1. METHODOLOGY

This report is based on qualitative, explorative needs based research. The data was collected by means of:

- selective literature search
- personal interviews
- questionnaires

For the purpose of this report, it was decided to use a modification of the Snowball Technique[1] as a means of information gathering.

This technique requires the initial identification of a knowledgeable person from the relevant area. This person is then asked to nominate others who are also regarded as knowledgeable and as the process continues the snowball effect is created.

The initial approach was made to the Confederation of Australian Motor Sports (C.A.M.S.) as the group responsible for the administration of all motor sport in Australia. C.A.M.S. endorsed the concept and supplied a list of main players who were then personally interviewed to identify main trends.

The parameters of the main player interviews were established from the results of a literature survey which looked at the use of modern technology and materials in the motor industry.

The trends identified by the main players were then analyzed to identify potential needs within the industry and these needs were used as a basis to develop a questionnaire.

The questionnaire was distributed to the managers of a range of Automotive Reconditioning businesses in each Australian State and Territory.

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1 ABRAHAMSON, M. (1983) Social Research Methods Prentice-Hall Inc. Englewood Cliffs

2. FIELD PERSPECTIVE

2.1 Motor Racing in Australia

Motor Racing in Australia has a long history, in fact the Australian Grand Prix is the second oldest event of its type in the world, the first race taking place at Phillip Island in 1928 was pre-dated by the French Grand Prix which was first staged in 1906. The vehicles used over the years have been generally "last years" European cars enabling the Australian Motor Industry to keep abreast with but not necessarily at the cutting edge of technology.

Despite hosting many "International" events, notably the Tasman Series during the late 1960's and 1970's, Australia had not run a world championship event until 1984 when the final round of the World Endurance Championship for Group C sports cars was held at Sandown. The following year saw for the first time, the running of the Australian Grand Prix as a round of the world championship series and the adoption of International Rules to local class racing with the introduction of Group A touring car regulations.

This trend has continued culminating in Australia hosting two world championship events on consecutive weekends, the Australian Grand Prix in Adelaide on November 13 and the final round of the World Endurance Championship at Sandown November 20th.

The future of these events is assured with the announcement during the Australian Grand Prix by the Federation Internationale du Sport Automobile (F.I.S.A.), the world governing body of motor sport, of an agreement for the continued support of Adelaide as the venue for the Australian Grand Prix for the next 7 years. Discussions with international competitors at Sandown by members of this research team, verify their strong support for the continuation of a world sports car championship at this venue.

2.2 High Performance Engines

By definition, a high performance engine can fall into several categories:

(1) A production engine that has been modified for increased power output.

(2) An engine produced by a quality car manufacturer.

(3) An engine designed specifically for racing.

All three vary considerably from the base product and require very high skill levels, both to prepare and maintain.

3. HIGH PERFORMANCE PRODUCTION ENGINES IN MOTOR RACING

3.1 Racing Categories and Regulations

The use of a production engine is necessary in certain categories of racing such as Formula Vee, Formula Ford, Group E & A Touring cars and rally cars.

The regulations in force for such classes of vehicles allow rebuilding of the engines to an exact, defined specification that limits capacity, compression ratio, valve and port size, valve timing and mass of components.

In Group A Touring Cars, certain freedoms are granted in the areas of compression ratio and valve timing, but strict regulation of venturi sizes and manufacturer's specifications are enforced.

Group E, no modifications are permitted, only the removal of the exhaust and shock absorbers may be changed.

Formula Vee and Formula Ford have extremely detailed specifications as to the type of engine used, the actual dimensions and weight of components and the machining tolerances permitted. Sports sedans allow unlimited modifications to the engine with an upper limit on engine capacity.

The introduction of National Association for Stock Car Auto Racing and

Australian Stock Car Auto Racing bring with them closely written regulations that cover the whole vehicle. The engines are specifically limited in capacity and the source of components such as the cylinder block, cylinder heads, camshaft, pistons, connecting rods, camshaft and rocker gear, carburettor type and size is also specified.

The new Formula Australia uses the new Holden Commodore 3.8 litre V6 engine. By specifying the engine to be used and applying dimensional constraints on the actual car, the promoters hope to encourage an increase in the number of chassis builders and engine preparation firms in this country. This will be Australia's premier open wheeler formula and according to one car construction engineer "will allow local chassis development and reduce costs for the competitor".

The aim of any set of regulations is to provide a set of rules that are fair and just for all competing vehicles and competitors. Vehicles can be classed according to engine size, price, body type, number of seats, method of aspiration, the type of fuel used.

From the competitors viewpoint, they will select a vehicle within the category that they race according to its make (to which they may have allegiance) or to its suitability or potential as a race winner.

If a certain make and model proves to be more successful, other competitors will quickly follow the lead (and sometimes the success) by purchasing similar vehicles. When one make of vehicle displays complete dominance within its class, the spectator appeal will diminish and attendance numbers will drop. Sponsors may become dissatisfied and withdraw support. To overcome this, governing bodies will often review the regulations to encourage the introduction of different makes to prevent one make dominance.

With regulations closely written and strict controls on fuels and engine specifications, it becomes the challenge of the vehicle owner, entrant, or preparer to develop the vehicle and its engine, within the spirit of the

regulations, to be as competitive as is necessary to win the races and the particular championship being contested - after all that is the aim for both the competitor and their sponsors.

The success of NASCAR in the U.S.A. cannot be denied, crowds of up to 200,000 spectators flock to the super speedways to witness the spectacle of 30-50 race cars, that are closely matched in specification, compete for huge amounts of prize money.

The anticipated success of the Australian version, AUSCAR, is based upon similar very tight and closely policed regulations. Billed as the world's most popular form of Motor Racing by Mr. Jane's latest radio advertisements, NASCAR/AUSCAR racing is certainly making its mark in Australia. This is evidenced by the million dollar prize money being offered for the December '88 meeting. Anyone who has followed motor sport, will bear witness to Bob Jane's transformation of Calder Park from a mud or dust bowl (depending on weather) to its present state as a motor racing complex.

The modern Calder Park boasts four different configurations of race circuit, permanent spectator facilities and paved service roads. The beginnings of a Technical Park/Industrial estate are also evident in the form of permanent workshops and the availability of race car preparation enterprises.

4. FINANCIAL SPONSORSHIP

A common factor of most successful competitors is a healthy financial budget which is usually provided by a sponsor. The willingness of a sponsor to support a racing team is often governed by the past results of that team and the likelihood of success. This success will bring kudos to the team and often a continuation of their sponsorship in future seasons. As stated by one team manager, "my sponsor has been with me for over ten years, but we give them their money's worth".

Most racing teams attract some sponsorship, the shortfall in operating costs is borne by the team itself, which is often one person, usually the driver. Sponsorship of a series of racing such as NASCAR or AUSCAR allows each "Association" to maintain regulations by using compulsory components subsidised by the manufacturer. This is both direct and indirect sponsorship.

The successful teams then, are those with the finances to buy the latest vehicle, the most current technology and the staff to organise the team as a professional, cohesive unit. These finances will also fund ongoing research into further developing the latent potential of their selected vehicle. Financial sponsorship can be seen as the stimulus for growth in all categories of racing according to most team managers and is the ambition of many budding competitors.

Over recent years there are an increasing number of sponsors willing to fund, with six figure budgets, racing teams because of the high profile of this sport. This has created a shortage of personnel with the skills necessary to prepare the engines for racing. The cost of engine preparation is extremely expensive because of the amount of hours required to develop the engine, from its basic form, or its designed purpose as a power unit for a passenger car, into a racing engine producing up to three times its original power output. The original methods of engine development were to alter components and try them out on the track. There was little science involved although the more successful teams got things wrong fewer times. Engines would be run until a component failed, that component would then be modified or reworked and tried again. If another component failed the process would be repeated. (The alteration of components would need to conform to the regulations otherwise the legality of these alterations would result in disqualification). The penultimate expression of this improvement method is the Aries Chevrolet engine which looks like a Chevrolet but is made from exotic materials and costs around $40,000.

Motor racing has never been a poor mans sport, but today a racing version

of a Holden V8 engine in Group A can be as high as $32,000, a BMW M3 engine up to $48,000, these being normally aspirated engines. Obviously any development on these engines will need to be carefully planned and checked to minimise the risk of destroying such valuable components (if not the engine).

5. SKILLED PERSONNEL

To plan, design, perform the modifications and evaluate the results will require skilled personnel. All team managers and vehicle preparers interviewed confirmed the shortage of such people, both within their own organisations and those of their competitors. There is also a shortage of firms in the Automotive Machinist field with the skilled tradesmen able to effectively liaise with the engine developers and perform the machining operations required. These services, when available, are expensive and usually confined to a comparatively small number of firms who have the expertise demanded. Professional preparers of racing vehicles and engines are therefore clear in their own minds of the alterations to be made to components and issue the instructions for machining. The private competitor however, will often rely upon firms to do the total preparation such as suspension alignment, gear box overhaul and the engine preparation. Alternatively they may rely on the Automotive Machining workshops to either machine the components for the owner to assemble, or carry out a full dismantle, prepare and assemble on the engine, for the owner to install. Regardless where these people come from, there is a strong reliance on the skills and knowledge held by the Automotive Machinist.

There is a concern expressed by vehicle preparers, team managers and competitors that there is often a lack of understanding of essential work practices usually held by competent tradespeople. For example -

(i) cleanliness when working on engine components during dismantling and assembly.

(ii) understanding of correct assembly procedures.

(iii) understanding of component operating principles and reasons for design change i.e., valve timing and its relation to power output and rev ranges.

(iv) lack of attention to detail.

6. HIGH LEVEL MULTI SKILL REQUIREMENTS

All indications from competitors, team managers, vehicle preparers and automotive machinist workshop owners are that the demand for services at all levels, and the need for a skilled and competent workforce, particularly in the engine machining trade, is increasing rapidly and currently the only source for skilled personnel is other teams.

Many of those interviewed, including international teams at the World Sportscar Championship event held at Sandown in November '88, were not in the business of training people, but preferred to "poach" workers of known ability from other teams. This could be seen as in-built, on the job training as workers, by moving from team to team obviously experienced different types of competition car together with quite possibly, a different approach to car preparation. This may be seen as an advantage to those already working in the high performance field, but it does indicate an inability to expand the pool of effective tradespersons whilst reflecting the Team Managers reluctance to expose expensive equipment and possibly life and limb to the "unknown".

The aspect of safety is an interesting one although it was not spoken about directly. It is apparent that this issue is foremost in the minds of a number of those interviewed. Indications are that prior knowledge of ability or experience of a prospective employee enables the Team Manager and drivers to have confidence in team members.

Skills such as engine blueprinting, balancing, deck heighting, compression ratio calculation, are but a few of the services required. As mentioned, the cost of complete engines is high and reflects the labour intensive

detail changes to convert a low priced raw product into a competitive racing engine.

All vehicle preparers and automotive machine workshop owners agree that those seeking a career in this industry will need to build upon good basic skills and a thorough theoretical knowledge of engine operation and power production. Being able to operate specialist equipment such as a dynamometer and cylinder head gas flow rigs will be a definite advantage if not a necessity, in the engine building business.

Motor sport in Australia has risen from its amateur and local status to the stage where we are competing with top professional European teams in international events.

7. THE OVERSEAS EXPERIENCE

Many Australians have ventured to the U.K. and Europe to take up employment as racing mechanics, team managers and racing drivers. These ambassadors have enhanced our national reputation as skilled and enthusiastic professionals. More recently, with Group A Touring Cars, local teams have taken their own cars overseas and competed against the multi million dollar European teams and have either won or have been in the major placings. With results like this there can be no doubt of our ability to compete in International Motor Sport.

8. SKILLS SHORTFALL

8.1 Entry Point

The favoured entry point to the industry was as a qualified tradesperson with wide experience on normal road cars. The high performance/race car preparation industry was not seen as an ideal apprenticeship training area as the skills learnt were too narrow.

A specific skill noted as not held by many of the mechanics/fitters

applying for positions in race teams was identified as M.I.G. and/or T.I.G welding. This was a commonly held view of those interviewed and considered necessary and normal to the job.

8.2 Non Trade Skills

In addition to trade based skills CAMS clearly identified other issues of skills shortages which have become apparent with the growth of the industry. These are predominately concerned with the supportive infra structure required by approximately 38,000 affiliated members and 162 Australian meetings each year.

8.3 Electronics

The most significant advancement in engine performance in recent times can be attributed to the adaptation of electronics and computer systems to the motor vehicle. Because these systems are able to tailor the fuel mixture and ignition spark timing to suit all conditions under which the engine operates, the system, correctly termed "an engine management system", maximum engine efficiency can be achieved both in terms of power and economy.

These systems are so effective, that engines, that were producing good reliable power outputs are now able to deliver even more power, to the detriment of mechanical reliability, which is then improved in the next update of engine specification.

The question of there being enough people with the necessary expertise in understanding the principles of engine management systems was addressed by people with backgrounds such as team managers, engineers and several competitors. This group identified the problem of the availability of personnel, with the particular skills that they require.

As one engineer stated, "without basic knowledge of these systems, the engine cannot even be started".

The media liaison representative of the Formula Two Association expressed concern about "a need for expertise in the area of microchip technology, re engine management systems".

The most disturbing trend indicated in this survey is in this rapidly expanding industry there just aren't enough skilled people to provide the services demanded by racing teams. The identification of such a shortfall of multi skilled workers indicates that the demand for such people has exceeded the supply, that this will of course tend to get worse as there is no viable source for the replacement of those that leave the industry through age or career opportunity. Obviously there is a need for new people in the industry, people with a successful basic automotive apprenticeship behind them and the usual youthful enthusiasm for their chosen sport. If they have the opportunity to experience further training in the appropriate multi skill topics, that have been identified as necessary in the industry, then they will be more productive at an earlier stage than is usually normal, where experience is gained over many years. That is not to say that a course of training can supplant years of experience, it would provide of course, the higher level of "basics" in a high technology sport where <u>everything</u> moves fast.

8.4 <u>"Lease" Engines</u>

Many of the private international teams spoken to during the World Endurance Championship at Sandown, lease their engines from manufacturers or specialist engine building preparation firms. These engines are run to a strict maintenance schedule being returned to their owners at regular intervals for maintenance and updating to latest specs. Examples of this would be the Cosworth V8 engine for which the majority of teams use the English firm of Nicholson-McLaren and the Porsche world endurance championship engine. The Porsche engine utilising many titanium components and a welding process to attach the cylinder heads to the cylinder bore. These two areas are not covered by basic training courses hence the necessity of using the original European manufacturer for service. This highlights the complexity both in design and materials used in the modern

racing power plant as most interviewed felt that they or their staff did not have the expertise to maintain these engines at their maximum performance level. It is the opinion of one Australian team manager, that without the necessary local technical staff, he may find it more economic to do the same with a Group A touring car. This means that local team engines will be sent overseas for repair.

8.5 Race Engineer

A number of competitors who were interviewed, including a racing car constructor, indicated that there is need for a new position of "engineer" with race teams, that is a person to fit between mechanic and Team Manager. This person would have the practical abilities of a mechanic combined with a theoretical knowledge of vehicle dynamics, his/her job would be to "set up" the car to suit particular conditions or circuits. This need is generated in several ways.

Firstly, the complexity of the current generation racing car, secondly, the competitiveness of formula type racing e.g., Formula Ford, Formula Vee and now Formula Holden, the rules for which are designed to produce cars of equal performance. Thirdly, the involvement of commercial sponsors who invest large sums of money into race teams with the expectation of success.

9. APPLICATION OF TECHNOLOGY

The automotive industry has never lacked "bright ideas". The past as well as the present has been littered with design concepts and innovations.

How then is the potential of a technical concept adapted for use by the motoring public? The answer is relevant to the training needs of engine reconditioners as the need for trained people will inevitably follow technological development and diffusion. It also follows that the high performance skills initially required by the few to utilize the new technology are the same that will be widely needed when the technology is used in production vehicles[2]. However, comparatively little of the available technology is finally used commercially and not all of it would require special training, particularly in the area of transient technology which involves successive generations of processes or materials. These progressive developments often incorporate new features or components which gain acceptance because of a proven record and the potential to improve performance. A significant component of the training needs may therefore be an adaptation or extension of the existing skills base.

In addition, any training which attempts to address the issue of technology must be sufficiently flexible to cater for the needs of a continuing process in which skills are constantly updated in response to the introduction of later technology. From a TAFE perspective the response to technological change centres upon the development of curriculum and the provision of resources required to implement the curricula. The development of curricula requires accuracy and the appropriate resources must be provided within a time frame which continues to tighten. In these days of economic constraint, it is essential to balance the need to be sensitive to emerging requirements of industry with the costs involved in satisfying these needs. The early and accurate identification of vocational training requirements is therefore very critical to TAFE,

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2 RITCHIE J.B. (1984) The Dynamics of Technological Advancement and Diffusion into Industry.
IN, MICROELECTRONICS TRAINING NEEDS REPORT.
National Training Council Canberra

particularly when the majority of the industry consists of small businesses most of whom have little opportunity for research and future planning to cater for the impact of new technology. If we can identify the viable new technologies early enough then we should be able to gain sufficient lead time to develop the training required by a modern competitive workforce at the time that it is needed.

In the motor industry most technical innovations are first trialled by specialist racers before being introduced to the domestic market. An examination of the process by which promising technological advances become commercial realities shows that the earliest practical time of identification occurs during the trialling period of motor racing. In this highly competitive business the costs are high, and to the winners, the rewards are great and any technological means of gaining a winning edge is quickly taken. Moreover any technological improvement that could be included is subjected to the most severe testing in the constant search for improved performance where the cost factors, efficiency and reliability are under constant review.

10. TECHNOLOGY AND SKILL DEVELOPMENT

The high technology transformation of the global automotive sector is increasing. Ceramic parts, fibre optics, composite materials, powdered metal alloys, cermets, engineering plastics, advanced sensors, display electronics, flexible manufacturing systems and CAD/CAM are redefining the way cars are designed and built. The next generation of automobiles will owe their heritage more to aerospace than to the auto sector of the seventies.

Even assuming the conservative path of the continued viability in the use of the internal combustion engine, technology can be used to increase efficiency. For example, if a turbo charged direct-injection diesel engine using some ceramic components in "hot areas", is coupled with a continuously variable transmission and placed in a small passenger car the size of a Toyota Corolla, a city test cycle could return results of about 3 litres per 100 kilometers[3].

Automotive manufacturers recognise that competitive advantage requires swift identification of the latest ideas and technologies from around the globe and that mastery of technology is now the means for achieving international competitiveness. The automotive primes have pursued a round of acquisitions and strategic partnerships to obtain an early awareness of the latest ideas and technologies and this restructuring has accelerated the infusion of advanced technology into the global auto sector[4]. It must also be recognised that as advanced technology becomes incorporated into the design of automobiles, we must ensure that the technical proficiency and knowledge of our technicians will continue to keep pace with those advances to provide the servicing required.

The availability of appropriate skills in adequate numbers is essential to

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3 ALTSHULER A., ANDERSON M., JONES D., ROOS D. & WOMACK J. (1984) The Future of the Automobile

4 RUBINGER B. & WEINER S.B. (1986) Accessing Japan's High Tech Progress: Guidelines for Auto Industry Pathfinders. S.A.E. Technical Paper Series No. 860519

the well being of an industry as it assists the industry's capacity to adapt to changing needs. An inadequate work force can thus have a negative effect on both the Government's objectives of international competitiveness and also on the expansion of an industry by limiting its ability to cope with the effects of introducing new technologies and materials[5].

In Australia the supply of skilled personnel for the automotive machining and reconditioning field is based upon our apprenticeship system. Some states such as Victoria, West Australia and Queensland, have specialist apprenticeships which provide specific training. Other states or territories base their training on parallel courses such as Fitting and Machining or Motor Mechanics. Trades people from these courses then transfer and refine their skills as required for automotive reconditioning. Whilst the alternative sources of expertise can provide a strong skill base due to its variety, it can also result in some shortfall in uniformity of skills and skill levels. This situation will have a significant effect upon the training and retraining needs of the industry.

The need for the adaption or extension of the existing skills base to cater for the effects of introducing new technology or materials is dependent upon what is introduced and the rate at which it is diffused into the industry.

> 'The fact is, however, that there is substantial evidence of skill deficiency problems caused by inadequate training responses to new technologies.' (Ritchie 1984)

The best possible response to emerging training needs will therefore be determined by our ability for early identification of viable technologies and materials and the accurate assessment of their assimilation rate.

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5 Australian Science and Technology Council (1987) p.4 Wealth from Skills Measures to RAise the Skills of the Workforce

11. OCCUPATIONAL LOSS OF SKILLS

The Victorian CES figures for November 1988 showed that there were 39 registered vacancies for Automotive Machinists. These shortages appear consistent with those experienced in a number of major occupations facing an increased demand for skilled labour and changes in the types of skills required.

One factor which appears important in explaining skill shortages in a number of occupations is the high rate at which skilled workers leave the occupations for which they are trained. While one would expect some workers to change occupations as a result of career development and incorrect decisions on career choice, ad hoc studies and anecdotal evidence suggest that the level of separation from some skilled occupations is cause for concern[6].

For all trades the rate of separation from the occupation in which an apprenticeship was completed (home occupation) increases with the time from qualification. Whilst there are no available statistics specifically for Engine Reconditioners or Automotive Machinists, the rates for Motor Mechanics of 45.3%, and Fitting/Turning and Toolmaking 41.9%, provide some comparison (see table 1).

The constant movement away from a home and vertically integrated occupation such as Engine Reconditioning (see fig.1) drains the occupational pool of at least basic skills.

This loss of occupational skills also tends to have an adverse effect on the provision of courses intended to upgrade skills. The structure and content of advanced courses should therefore be designed to encourage participation. The structure should be flexible to allow each worker to acquire the specific skill which they or the firm need. The credentialling system should recognise the gaining of each skill. The content of courses

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6 THOMAS C. (1988) Separation from the Trades Discussion Paper No. 2
Department of Employment, Education and Training Economic Division

must reflect the variation of occupational needs.

TABLE 1 : PERSONS AGED 15-64 YEARS HOLDING TRADE QUALIFICATIONS IN SELECTED FIELDS - RATES OF SEPARATION FROM HOME OCCUPATION/S, BY YEARS SINCE QUALIFICATION AUSTRALIA, 1981

FIELD OF QUALIFICATION	TOTAL WITH QUALIFICATION	YEARS SINCE QUALIFICATION						
		<1	1-4	5-9	10-14	15-19	20+	TOTAL
METAL TRADES		%	%	%	%	%	%	%
FITTING, TURNING & TOOLMAKING	114,100	21.2	35.1	47.3	56.6	62.4	65.6	53.7
WELDING & BOILERMAKING	42,300	27.9	42.1	49.2	52.8	56.9	58.8	50.0
SHEETMETAL WORKING	12,000	21.6	37.7	49.2	59.8	63.8	68.3	54.8
ELECTRICAL TRADES	90,400	20.8	27.1	35.4	41.4	45.2	53.4	40.7
BUILDING TRADES								
CARPENTRY & JOINERY	89,400	22.6	38.0	47.7	57.0	62.6	67.4	55.7
BRICKLAYING	20,200	20.0	31.9	34.1	36.4	40.9	54.2	42.5
PAINTING & DECORATING	34,200	24.9	39.6	44.6	43.0	45.1	47.5	43.4
CONCRETING, PLASTERING & MASONRY	10,800	35.8	50.4	49.0	54.0	55.1	68.4	57.0
PLUMBING & GASFITTING	42,900	17.7	27.4	33.5	37.4	41.0	48.0	39.2
PRINTING TRADES	34,100	24.6	36.9	44.1	52.0	54.9	57.4	50.8
VEHICLE TRADES								
AUTOMOTIVE MECHANICS	64,600	27.7	39.5	50.5	57.7	63.1	67.4	54.4
PANEL BEATING	18,100	24.8	45.6	51.5	53.2	55.5	63.3	51.3
BUTCHERING	29,100	18.8	40.5	46.9	52.1	53.4	56.8	49.5
FURNITURE TRADES	27,100	20.2	40.8	54.2	61.6	65.7	73.4	59.3
BARBERING & BEAUTY CULTURE	59,100	22.8	40.7	65.2	77.5	78.7	83.4	67.9

SOURCE . ABS, 1981 Census of Population and Housing

TABLE 1 - PERSONS AGED 15-64 YRS HOLDING TRADE QUALIFICATIONS IN SELECTED FIELDS

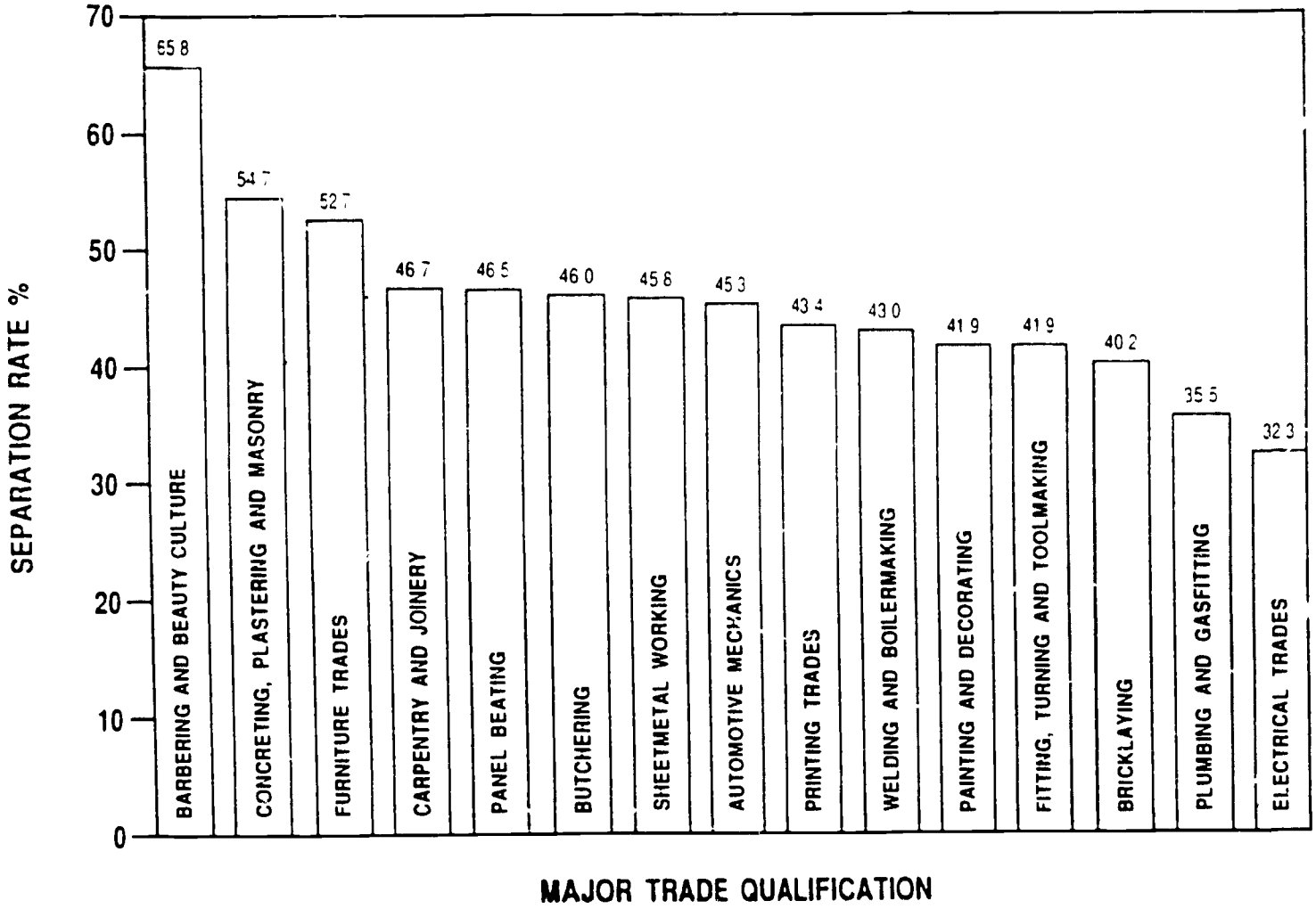

FIGURE 1 - MAJOR TRADES QUALIFICATIONS - RATES OF SEPARATION

12. INCENTIVES FOR UPGRADING SKILLS

The problem of small firms having access to current or updated skills in order to remain competitive is a difficult one. Human Capital Theory (H.C.T.) is concerned with the amount of training undertaken by firms and individuals. It suggests that a firm will undertake training if the benefits exceed the costs. In the past very few small firms have made a serious effort to provide any course of training apart from that of basic apprenticeships. Most tend to rely upon skills being acquired elsewhere and so have little if any experience in accurately assessing the cost/benefit relationship of training. The training benefits are influenced by a number of factors including:

- The type of skills imparted. HCT predicts that firms will tend to provide firm-specific skills rather than general skills which are transferrable among firms.

- The period for which trainees remain with the firm. If skilled workers leave soon after receiving their training, the firm's investment is unlikely to be profitable. Conversely, the more stable the firm's workforce, the higher the return to investment in training.

- Investment in training is clearly quite risky. Employees may be unable or unwilling to master the new skills, employees may leave soon after acquiring the skills or the skills themselves may become obsolete very quickly as a result of technological change.

HCT does not explain, by itself, why Australian firms tend to invest less in training than firms in some other countries. However, it does emphasis the importance of a stable workforce in increasing the profitability of training. Hence HCT would predict that the relatively high turnover rate of Australian labour (OECD 1984) would be one factor explaining why

Australian firms invest less in training[7].

The incentive for individuals to upgrade their skills may be motivated by either a desire to increase their competence or to improve their earnings. These individuals could be encouraged by recent developments, in expanding the award structure, which allow for increased remuneration in recognition of the multiskilling of workers. Usually this broadening of skills is also concerned with the development of conceptual skills such as those required by the introduction of Computer Numerically Controlled (C.N.C.) Technology. In the future this acquisition of skills may also lead to a breaking down of some of the traditional barriers that currently exist between trades.

The loss of occupational skills also tends to have an adverse effect on the provision of courses intended to upgrade skills. The structure and content of advanced courses should therefore be designed to encourage participation. The structure should be flexible to allow each worker to acquire the specific skill which they or the firm need. The credentialling system should recognise the gaining of each skill. The content of courses must reflect the variation of occupational needs. A report from the Australian Science and Technology Council (ASTEC) encourages the use of open learning approaches to achieve this flexibility[8].

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7 KREAVAC L. & STRETTON A. (1988) p.7 Skill Formation and Structural Adjustment the Responsiveness of Industry Training. Discussion Paper No. 3.
Department of Employment, Education and Training Economic Division

8 Australian Science and Technology Council (1987) p.31 Wealth from Skills Measures to Raise the Skills of the Workforce

13. RESULTS

13.1 Identified Trends

Interviews were conducted at interviewees premises and at several race meetings. It was decided that National competition events afforded the best opportunity for interviewing a broad range of local, interstate and international teams, thus gaining a general overview of Australian racing.

The nature of the Industry was highlighted by the difficulty in accessing key players both by mail and in person. As our timing coincided with a series of major race meetings, the timing of interviews with those in the industry was, of necessity around motor racing commitments, with in some cases, blank refusal until after the next race meeting. Machine shops involved with teams were in a similar position. The busy schedule now required by Australian participants confirms the growth of the industry and the necessity for participants continuous involvement.

All indications from the research conducted in this project show that motor racing is a growing sport that offers sponsors high profile exposure for their goods and products. With this appealing feature, advertising and marketing firms encourage their large account clients to enter into sponsorship deals with the more successful racing teams. This can be evidenced by the improved telecasts for events such as Bathurst 1000, the Australian Grand Prix, the World Endurance Cup, Formula One races and most local and interstate events. This has led to the development of sophisticated in-car camera, ("Race Cam") which has been sold overseas. The latest Australian development being an in-car computer system which provides the viewer with actual vehicle performance data (Netcomm). These advancements further increase the appeal of television coverage for the team sponsors.

The ability of any team to be successful will depend upon their quality of vehicle preparation, team management and team skills level. The quality of services available to the teams for specialty skills, such as automotive machining, is of paramount importance in engine preparation. Our research

shows that currently the professional vehicle preparation firms in Victoria tend to favour a limited number of workshops, the same happens in other states, (it is not unusual for rival teams to have their components side by side in one workshop).

The engine machine shops themselves agreed that there is a constant shortage of machinists, those with the necessary skills and the level of mechanical understanding needed to competently prepare an engine for racing.

If an apprentice has satisfactorily completed the basic apprenticeship course and is considered to have a good understanding of the way an engine works (and the conditions under which it works), they could then be in a good position to later broaden and upgrade their skills to prepare them as future employees for racing engine preparation.

By developing suitable courses of training in the specialized areas identified in this project, a means of gaining the higher level of specific skills within each area would be available for the individual and the motor racing industry.

14. QUESTIONNAIRE SURVEY

14.1 Responses

A total of 221 questionnaires were mailed to the managers of randomly selected engine reconditioners in each Australian state or territory (see Table 2). Unfortunately this mailing date coincided with a disruption of mail services and the full effect of this on delivery is unknown. A follow up letter was forwarded one week later to encourage responses. It is interesting to note that several interstate managers telephoned the sender and said that they had not received the original questionnaire. Most of these also took the opportunity to express their concern over the provision of training in their respective localities. A total of 73 replies were received to give a response rate of 34%.

14.2 General Information

The responses show Engine Reconditioners are typically small firms with an average workforce of 7 skilled workers. In the opinion of 96% of managers, their new staff usually required some training to satisfy the particular requirements of the new position. It should not be assumed however, that this training only related to advanced skills for although the survey focuses on the need for advanced or post apprenticeships skills, many of the respondents comments were also concerned with the provision of basic skills.

As the average age of the surveyed skilled staff is approximately 30 years, it can be estimated (From Table 1) that the loss to the industry of these particular workers over the next 5 years will be approximately 50%. Given the factors of the current widespread shortage of adequately trained personnel as confirmed by 92% of the respondents, and the anticipated loss of current workers, it seems most unlikely that the future supply of skilled workers will improve unless there is a major revision of our present training provision.

TABLE 2

BREAKUP OF MAIL TO STATES

	SENT	RETURNED	RETURNED TO SENDER
NEW SOUTH WALES	40	13	2
AUSTRALIAN CAPITAL TERRITORY	7	2	-
VICTORIA	77	21	5
QUEENSLAND	31	13	2
SOUTH AUSTRALIA	22	7	-
NORTHERN TERRITORY	4	2	1
WESTERN AUSTRALIA	31	6	-
TASMANIA	9	3	-
NOT KNOWN	-	4	-
TOTAL	221	73	10

COMPLETED RETURN RATE - 34%

Very few of those contacted had yet any experience in working with the advanced materials of carbon fibre (8%), ceramics (18%). titanium (26%) or aramid fibres (2%). Only 43% of respondents required their staff to have an understanding of electronic management systems.

14.3 Specific Course Information

Respondents were asked to add their suggestions to a list of areas for a proposed course of advanced skills. Several of their comments (Appendix 1) were the same as, or very similar to, topics contained in our suggested areas which tended to confirm the proposed outline. Other suggestions included an understanding of alternate fuels and C.N.C. programming and operation.

Responses to the specific course information section strongly reinforced both the previously identified need for an advanced course and its major content areas. However, whilst the specific topics confirm the content areas, their inclusion in a new course should be the result of further occupational analysis.

Although not all respondents answered each question (Appendix 2) the replies relating to topics, to be included in the suggested areas, showed that a clear majority were in their favour (Appendix 3). For example, Table 4 shows that the average percentage of those who strongly agreed to the topics in the area of Engine Assembly was 53%, those who agreed averaged 34%, an average of 9% didn't know, 4% disagreed and only 1% strongly disagreed. A similar pattern of support is apparent for topics in each of the other proposed areas with the highest rate of dissent (average 13%) occurring in the area of welding and fabrication.

TABLE 3

AVERAGE REPLY RATE TO TOPICS, BY AREAS

CONTENT AREA	STRONGLY AGREE %	AGREE %	DON'T KNOW %	DISAGREE %	STRONGLY DISAGREE %
ENGINE ASSEMBLY & BLUE PRINTING	53	34	0	4	1
PRECISION MACHINING OF COMPONENTS	40	38	10	5	1
ENGINE TESTING AND EVALUATION	34	52	13	1	0
WELDING AND FABRICATION	25	40	17	13	5

NOTE: The above figures have been rounded off to the appropriate number.

14.4 Comments

Many managers took advantage of the opportunity to comment on specific course information and their responses reflect the diversity of the trade. Whilst the majority concentrated on relevant issues, some diverted a little too far from the subject and so have been deleted from the list provided (see Appendix 4).

Whilst the Engine Reconditioners survey was intended to concentrate upon the need for advanced skills, it was perhaps inevitable that the problem of skill shortages at other levels would also be raised. This consistently occurred in the comment area of the questionnaire and was particularly evident in returns from states and territories which do not have a specialised apprenticeship course. For example, one manager said:

> ".....being an Engine Reconditioner for 25 years, I feel this questionnaire is fine for High Performance needs, but I would like to say that the "WHOLE TRAINING" of Engine Reconditioners

needs to be addressed. There is a need for a TAFE course dealing specifically with Engine Reconditioning. This would entail training on all machinery and other aspects of the reconditioning game. If you start with this and then follow with specialised courses outlined in your questionnaire, then you will produce the specialised engine reconditioners of the future."

15. CONCLUSION

This project has clearly identified a need for a post-apprenticeship course that will provide an advanced level of technological skills for the machining, building and operation of high performance engine and mechanical components in the following areas:

(a) Precision machining of components
(b) Engine design considerations
(c) Engine assembly and blue printing
(d) Engine testing and evaluation
(e) Welding and fabrication

The current growth of various forms of motor racing under the jurisdiction of C.A.M.S. can be expected to continue with the involvement of both local and international competitors. The infra structure required to support this industry includes the need for a person, with a range of skills appropriate to the application of new technologies and materials, who is involved in the preparation of vehicles for racing. The specialist skills developed for use in the area of high performance engines and allied components may also be appropriate for later use by Engine Reconditioners in the maintenance of vehicles used by the general public.

The shortage of tradespeople which has been experienced by Engine Reconditioners over the last few years, will continue unless there are substantial changes to the current approaches to training. Traditionally, apart from initial training provided by the apprenticeship system, training for the broadening and upgrading of skills has received very little attention from most small Australian firms. This approach may need revising so that the Engine Reconditioning Industry has an available workforce of appropriate numbers and skill levels.

Whilst this project was intended to concentrate on the need for advanced skills, many managers are also concerned about initial training. This was particularly evident in those areas that do not have convenient access to apprenticeship courses such as Automotive Machining.

An incentive for tradespeople to participate in training programs, designed to broaden and upgrade their current skills, may be provided by new wage fixing arrangements. Adults may also be encouraged to participate by ensuring that the course is designed to cater for the needs of the individual by utilizing Open Learning Strategies.

A P P E N D I X 1

RESPONDENTS COMMENTS

OUTLINE OF PROPOSED COURSE

Suggestions for other areas:

f) An apprenticeship for Engine Reconditioners as such in Tas. (n)

* * *

f) Basic Mechanics of Engines

* * *

f) Camshaft Technology

* * *

f) Balancing by use of heavy metal.
g) EFI black box modification.

* * *

f) My suggestion is no. (a) [Precision machining of components].

* * *

f) Cylinder head air flow testing.
g) Modification for specific applications.

* * *

f) Cylinder head modifications.

* * *

f) CNC programming & operation.

* * *

f) Mechanic/Fitter Machinist as ONE TRADE not just for performance engines but for every engine. The technology is getting so advanced in our shop one man is used in all aspects of lathe/mills building engines and tuning cars etc. Should be a Tech course on its own.

* * *

f) Time Management.

* * *

f) Make no 1 - combine above subjects with productivity, time and motion.
g) Common sense application combined with a detailed analysis programme.

* * *

f) Crankshaft Journal Regrinding.

* * *

f) Understanding of alternate fuels.
g) Methane and ethyl etc (foreseeing fuel crisis), alternate materials (plastics, ceramics).

* * *

f) Engine Product Knowledge - aftermarket comp.

* * *

f) Cylinder head design variations & new technology.
g) Updating of tolerances and tension data etc.

* * *

f) Understanding of Engine Management Systems.
g) Understanding of Instruments for the testing of hi-performance engines e.g., 4 gas analyzers and scopes.

* * *

f) That apprentices from Tasmania be included in the training program.

APPENDIX 2

ACTUAL RESPONSES

GENERAL INFORMATION

1. Company Name (optional): _____

2. State or Territory:

NSW	ACT	VIC	QLD	SA	NT	WA	TAS	UNKNOWN	TOTAL REPLIES
13	2	21	13	7	2	6	3	4	71

3. Number of Skilled Staff: | 6.6 | (Average)

4. Average age of Skilled Staff: | 29.7 |

5. Do your new staff usually require training to satisfy your particular requirements?

Yes	No
68	3

6. Do you find that there are sufficient numbers of adequately skilled personnel within the industry?

Yes	No
5	66

7. Do your staff require an understanding of electronic engine management systems?

Yes	No
30	39

8. Do you have any experience in working with the following materials?

	Yes	No
a) carbon fibre	5	60
b) ceramics	12	54
c) titanium	17	49
d) aramid fibres	1	63

9. Do you feel that there is a need to develop an advanced course for high performance engines?

Yes	No
54	17

SPECIFIC COURSE INFORMATION

i. The following topics are needed in the area of ENGINE ASSEMBLY & BLUEPRINTING.

Please indicate your response to the above statement by placing a tick ( ) in the appropriate column.

TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.1 DECK HEIGHT PISTONS.....	43	25		1	
.2 BEARING FITTING.....	49	18			
.3 COMP. RATIO CHECK & CALCULATIONS...	38	24	2	4	
.4 DEGREEING IN A CAMSHAFT.....	48	16	2	3	
.5 DETAIL ASSEMBLY.....	49	16	2	1	
.6 MODIFY LUBRICATING SYSTEMS.....	32	20	3	5	
i) Rebuilding oil pumps.....	38	22	4	2	
ii) Build dry sump systems.....	18	25	14	4	1
.7 TURBOCHARGER OVERHAUL.....	24	28	13	5	
.8 ENGINE BLUE PRINTING.....	32	30	4	3	
.9 FASTENERS.....	22	26	11	1	

YOUR COMMENTS (IF ANY):

SPECIFIC COURSE INFORMATION

2. The following topics are needed in the area of PRECISION MACHINING OF COMPONENTS.

Please indicate your response to the above statement by placing a tick ( ) in the appropriate column.

	TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.1	CRACK TESTING.....	49	19			
	a) Pistons.....	38	25	1	4	
	b) Rods.....	42	26			
	c) Bolts.....	35	28	1		
	d) Axle shafts.....	34	22	3	4	
	e) Crankshafts.....	49	19			
	f) Blocks.....	40	25	1		1
.2	CYLINDER BLOCK SURFACING/DECKING...	43	24			
.3	GAS FLOW CYLINDER BLOCKS.....	18	25	18	6	1
.4	ANGLE MILL CYLINDER HEADS.....	20	27	13	5	1
.5	"O" RING CYLINDER BLOCKS.....	23	31	7	4	
.6	HONING CYLINDERS WITH STRAIN PLATE.	35	25	4	1	1
.7	INLET MANIFOLD MACHINING (V8).....	30	33		1	1
.8	MAIN BEARING TUNNEL BORING.....	38	25	1	3	
.9	MAIN BEARING LINE HONING.....	30	26	4	1	1
.10	MACHINE HEADS FOR LARGE VALVES.....	29	32	2	4	
.11	MACHINE COMBUSTION CHAMBERS.....	30	27	5	3	1

2. (Continued....)

TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.12 DYNAMIC BALANCE COMPONENTS.....	38	25		2	
.13 STATIC BALANCE COMPONENTS.....	27	30		4	1
.14 MACHINE FLYWHEELS.....	34	34			
.15 MACHINE AXLE HOUSINGS.....	8	18	24	9	3
.16 MACHINE BRAKE COMPONENTS.....	10	18	20	10	3
.17 MACHINE PISTONS.....	30	25	5	2	1
.18 TRANSMISSION COMPONENTS.....	10	15	26	9	3
.19 MAKE DRIVE SHAFTS.....	10	20	19	9	3

YOUR COMMENTS (IF ANY):

SPECIFIC COURSE INFORMATION

3. The following topics are needed in the area of ENGINE TESTING AND EVALUATION.

Please indicate your response to the above statement by placing a tick ( ) in the appropriate column.

	TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.1	DYNOMOMETER - OPERATION/TYPES.....	26	34	4		
.2	GAS FLOW CYLINDER HEADS.....	25	26	10	1	
.3	THEORETICAL KNOWLEDGE OF POWER DEV.	23	33	5	2	
.4	THEORY OF ENGINE BALANCE.....	28	35	4		
.5	ENGINE EFFICIENCY.....	23	35	4		
	FRICTION.....	21	38	7		
	VOLUMETRIC.....	18	38	9		
	I.P., B.P. ETC.....	13	26	13		
.6	ON-BOARD ELECTRONIC MEAS. DEVICES..	15	30	16	3	

YOUR COMMENTS (IF ANY):

SPECIFIC COURSE INFORMATION

4. The following topics are needed in the area of WELDING AND FABRICATION.

Please indicate your response to the above statement by placing a tick ( ) in the appropriate column.

TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.1 MODIFY HEADS BY WELDING & MACHINING	29	26	1	4	1
.2 MAKE OR MODIFY SUMPS.....	22	30	4	5	1
.3 MAKE OR MODIFY SUSPENSION PARTS....	10	16	11	14	7
.4 MAKE OR MODIFY ENGINE MOUNTINGS....	11	23	14	10	4
.5 MAKE OR MODIFY CLUTCH HOUSINGS.....	11	21	17	8	3
.6 MAKE OR MODIFY GEARBOX HOUSINGS....	8	23	15	9	3
.7 MAKE OR MODIFY CHASSIS FRAMES.....	10	15	16	16	4
.8 INLET SYSTEMS.....	17	35	6	1	1
.9 EXHAUST SYSTEMS.....	17	30	6	2	1
.10 ROLL CAGES.....	14	20	11	9	4

YOUR COMMENTS (IF ANY):

APPENDIX 3

QUESTIONNAIRE REPLIES - AS A PERCENTAGE

GENERAL INFORMATION

1. Company Name (optional): _____

2. State or Territory: _____

3. Number of Skilled Staff: [ ]

4. Average age of Skilled Staff: [ ]

*Please note: all of the following figures have been rounded off to the appropriate number.

5. Do your new staff usually require training to satisfy your particular requirements?

Yes	No
96%	4%

6. Do you find that there are sufficient numbers of adequately skilled personnel within the industry?

Yes	No
7%	93%

7. Do your staff require an understanding of electronic engine management systems?

Yes	No
43%	57%

8. Do you have any experience in working with the following materials?

	Yes	No
a) carbon fibre	8%	92%
b) ceramics	18%	82%
c) titanium	26%	74%
d) aramid fibres	2%	98%

9. Do you feel that there is a need to develop an advanced course for high performance engines?

Yes	No
76%	24%

SPECIFIC COURSE INFORMATION

1. The following topics are needed in the area of ENGINE ASSEMBLY & BLUEPRINTING.

Please indicate your response to the above statement by placing a tick ( ) in the appropriate column.

TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.1 DECK HEIGHT PISTONS.....	63%	36%	0%	1%	0%
.2 BEARING FITTING.....	73%	27%	0%	0%	0%
.3 COMP. RATIO CHECK & CALCULATIONS...	56%	35%	3%	6%	0%
.4 DEGREEING IN A CAMSHAFT.....	71%	24%	4%	1%	0%
.5 DETAIL ASSEMBLY.....	72%	23%	3%	2%	0%
.6 MODIFY LUBRICATING SYSTEMS.....	54%	33%	5%	8%	0%
i) Rebuilding oil pumps.....	57%	34%	6%	3%	0%
ii) Build dry sump systems.....	29%	40%	23%	7%	1%
.7 TURBOCHARGER OVERHAUL.....	34%	40%	19%	7%	0%
.8 ENGINE BLUE PRINTING.....	46%	44%	6%	4%	0%
.9 FASTENERS.....	36%	44%	19%	1%	0%

* (Please note: All of the above decimal figures have been rounded off to the appropriate decimal poirt.)

YOUR COMMENTS (IF ANY):

SPECIFIC COURSE INFORMATION

2. The following topics are needed in the area of PRECISION MACHINING OF COMPONENTS.

Please indicate your response to the above statement by placing a tick ( ) in the appropriate column.

TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.1 CRACK TESTING	72%	28%	0%	0%	0%
a) Pistons	56%	36%	2%	6%	0%
b) Rods	62%	38%	0%	0%	0%
c) Bolts	55%	44%	1%	0%	0%
d) Axle shafts	54%	35%	5%	6%	0%
e) Crankshafts	72%	28%	0%	0%	0%
f) Blocks	60%	38%	1%	0%	1%
.2 CYLINDER BLOCK SURFACING/DECKING	65%	35%	0%	0%	0%
.3 GAS FLOW CYLINDER BLOCKS	27%	36%	27%	9%	1%
.4 ANGLE MILL CYLINDER HEADS	30%	41%	20%	8%	1%
.5 "O" RING CYLINDER BLOCKS	36%	47%	11%	6%	0%
.6 HONING CYLINDERS WITH STRAIN PLATE	53%	38%	7%	1%	1%
.7 INLET MANIFOLD MACHINING (V8)	46%	52%	0%	1%	1%
.8 MAIN BEARING TUNNEL BORING	57%	37%	1%	5%	0%
.9 MAIN BEARING LINE HONING	49%	42%	7%	1%	1%
.10 MACHINE HEADS FOR LARGE VALVES	44%	47%	3%	6%	0%
.11 MACHINE COMBUSTION CHAMBERS	46%	41%	7%	5%	1%

2. (Continued....)

TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.12 DYNAMIC BALANCE COMPONENTS.....	59%	39%	0%	2%	0%
.13 STATIC BALANCE COMPONENTS.....	44%	48%	0%	7%	1%
.14 MACHINE FLYWHEELS.....	50%	50%	0%	0%	0%
.15 MACHINE AXLE HOUSINGS.....	13%	28%	39%	15%	5%
.16 MACHINE BRAKE COMPONENTS.....	16%	30%	33%	16%	5%
.17 MACHINE PISTONS.....	48%	40%	8%	3%	1%
.18 TRANSMISSION COMPONENTS.....	16%	24%	41%	14%	5%
.19 MAKE DRIVE SHAFTS.	16%	33%	31%	15%	5%

* (Please note: All of the above decimal figures have been rounded off to the appropriate decimal point.)

YOUR COMMENTS (IF ANY):

SPECIFIC COURSE INFORMATION

3. The following topics are needed in the area of ENGINE TESTING AND EVALUATION.

Please indicate your response to the above statement by placing a tick ( ) in the appropriate column.

	TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.1	DYNOMOMETER - OPERATION/TYPES.....	39%	55%	6%	0%	0%
.2	GAS FLOW CYLINDER HEADS.....	40%	42%	17%	1%	0%
.3	THEORETICAL KNOWLEDGE OF POWER DEV.	37%	52%	8%	3%	0%
.4	THEORY OF ENGINE BALANCE.....	42%	52%	6%	0%	0%
.5	ENGINE EFFICIENCY.....	37%	57%	6%	0%	0%
	FRICTION.....	32%	58%	10%	0%	0%
	VOLUMETRIC.....	28%	58%	14%	0%	0%
	I.P., B.P. ETC.....	25%	50%	25%	0%	0%
.6	ON-BOARD ELECTRONIC MEAS. DEVICES..	23%	47%	25%	5%	0%

* (Please note: All of the above decimal figures have been rounded off to the appropriate decimal point.)

YOUR COMMENTS (IF ANY):

SPECIFIC COURSE INFORMATION

4. The following topics are needed in the area of WELDING AND FABRICATION.

Please indicate your response to the above statement by placing a tick ( ) in the appropriate column.

TOPIC	STRONGLY AGREE	AGREE	DON'T KNOW	DISAGREE	STRONGLY DISAGREE
.1 MODIFY HEADS BY WELDING & MACHINING	48%	43%	1%	7%	1%
.2 MAKE OR MODIFY SUMPS.....	36%	48%	7%	8%	1%
.3 MAKE OR MODIFY SUSPENSION PARTS....	17%	32%	19%	24%	12%
.4 MAKE OR MODIFY ENGINE MOUNTINGS....	18%	37%	23%	16%	6%
.5 MAKE OR MODIFY CLUTCH HOUSINGS.....	18%	35%	29%	13%	5%
.6 MAKE OR MODIFY GEARBOX HOUSINGS....	14%	40%	26%	15%	5%
.7 MAKE OR MODIFY CHASSIS FRAMES.....	16%	25%	26%	26%	7%
.8 INLET SYSTEMS...	29%	59%	10%	1%	1%
.9 EXHAUST SYSTEMS.....	30%	54%	11%	4%	1%
.10 ROLL CAGES.....	24%	35%	19%	16%	6%

* (Please note: All of the above decimal figures have been rounded off to the appropriate decimal point.)

YOUR COMMENTS (IF ANY):

APPENDIX 4

RESPONDENTS COMMENTS

SPECIFIC COURSE INFORMATION

1. The following topics are needed in the area of ENGINE ASSEMBLY AND BLUEPRINTING.

COMMENTS:

As you well know, there is a chronic shortage of Auto Machinists for day-to-day workshop work. I hope the major effort & resources are kept training "starters" rather than producing specialists for competition vehicles.

REGARDS.....

* * *

What do you mean "blueprinting"? I have been building series production and f/ford engines for 15 years and the term blueprinting is probably the most misused terminology in the motor trade. We also race for T/Cam and BDA engines ourselves as well as building them for others.

* * *

Blueprinting is compulsory as far as engine performance is concerned, with the secret being - keep 100% concentration.

* * *

It is my opinion that a special course is not warranted. If a person wishes to pursue this type of career you undoubtedly find your experience by practical experience in the workshops which carry out this type of work. A good proportion of this proposal is covered by standard engine reconditioning course now available.

* * *

It is my opinion that a course as indicated is jumping the gun. The engine Reconditioning Industry requires tradespersons with a good basic knowledge of engine reconditioning.

* * *

Greater need for detailed camshaft operation.

* * *

I would have though each engine reconditioning apprentice would be expected to be capable of performing the tasks with which I have agreed.

* * *

Modify wet sump with baffles to stop surge. (.6 ii)
Piston to valve clearance check. (.4)

* * *

Training is required to develop understanding as to why the above items are important.

* * *

It would be desireable to have an understanding of the air-flow and breathing characteristics controlled by the induction system, cylinder head ports Cam timing - lift and exhaust system.

* * *

Dependent on engine type and such as decki_ pistons it depends on which brand as most forged units are quite accurate.

* * *

Dear Sir, although some merit may be gained by conducting such a course, I feel the problem should be addressed as what is being done to provide a course for basic Engine Reconditioning. The majority of engine reconditioners in Australia are always seeking skilled/trained personnel more apt to the repairing of Diesel/Petrol engines, a limited few specialise in high performance engine modifications. Your interest is appreciated, but your direction could be well awarded in another area. Yours faithfully, (name supplied).

* * *

Dear Sir, Being an Engine Reconditioner for 25 years, I feel this questionnaire is fine for High Performance needs, but I would like to say that the "WHOLE TRAINING" of engine reconditioners needs to be addressed. There is a need for a TAFE course dealing specifically with Engine Reconditioning. This would entail training on all machinery and other aspects of the reconditioning game. If you start with this and then follow with specialised courses outlined in your questionnaire, then you will produce the specialised engine reconditioners of the future.

* * *

SPECIFIC COURSE INFORMATION - Continued...

Compression ratio check, heads excessively machine, lifter crush, renew oil pumps, metal fatigue of drives fail when oil pressure increased.

Con rod and main and head bolts should be replaced. Excess torquing, thread stretch, twist etc...

* * *

We must narrow the definition of Engine Reconditioner. "Jack of all Trades, Master of none". Manufacture of non-reconditional engines creating unemployment.

* * *

Most of the topics listed are basically straight forward. Deck heights, bearing fitting, comp. ratio are all calculated for you in many catalogues. Maybe an understanding of all types of engines and how they work might help in this area of ass. Most leading race type engine assembly rely on machine shops to supply components and are basically selling their knowledge with engines built.

* * *

The teachers firstly have to be motivated in technology advancement and skills.

I might sound like a case of sour grapes, but I would do anything to advance the level of skills and tradespeople in engine reconditioning, assembly and dyno with correct application.

My whole life and business evolves around high performance. In ... I have given up the cause and live in my own "Little World" - (name supplied)

P.S. Keep up the effort!!! - Many, many thanks!!!

* * *

The current course does not emphasize the importance of any of the above.

* * *

SPECIFIC COURSE INFORMATION - Continued...

Degreeing and stroking crankshafts.

* * *

Bearing fitting should include grinding of C/shafts to suit fitted brgs to obtain correct clearance.

* * *

Checking off geometry.

SPECIFIC COURSE INFORMATION - Continued...

2. The following topics are needed in the area of PRECISION MACHINING OF COMPONENTS.

COMMENTS:

Strongly disagree on Q.9. as if main tunnels are tunnel bored correctly, is no need for honing. Answer to Q.6. - your question should read BORE & HONE with string plate not just hone from scratch, as some tend to do.

* * *

.1 (f) Blocks & heads should be pressure tested.
.1 (a) Pistons should be replaced as crack testing would make the cost of most engines prohibitive.
.1 (c) Bolts should be replaced if in doubt.

3,5,9,10,11. In our line of busine_ we do standard production engine reconditioning. We would not normally line bore or hone tunnels unless some damage had been caused by failure of components.

.17 We sometimes cam grind pistons only if we cannot buy the right pistons.

* * *

What about: resize con rods, fitting bushes and gudgeon pins, fitting inserts, fitting and reaming valve guides, etc etc - Basic Engine Reconditioning Requirements.

* * *

Gas flow - see next subject. Other don't know's - don't do enough of it to be in a position to comment.

* * *

(.13) Motor bikes only.

* * *

The ones I disagree with are only for high performance engines (5, 7, 10, 11, 12, 13, 17)

* * *

SPECIFIC COURSE INFORMATION - Continued...

The basic courses as presented to apprentices at the moment are boring. The average or above average would become more enthused in his work as a result of the above courses. This increased awareness and enthusiasm would be reflected through the ENTIRE TRAINING PROGRAM.

* * *

Please include grinding and finishing preparation of crankshafts and resizing of con rods and correcting for center to center lengths of con rods.

* * *

(.17) Depends on the purpose e.g., to lower compression ratio. O.K. providing plenty of thickness in head.

* * *

ALL machining should be precision!!!

* * *

Obviously all the above would by the ultimate course, but only a very limited amount of machine shops would have facility for all these operations.

* * *

N/A response indicates not applicable to our business - but agree needs to be included (.1d, 3, 13, 15, 16, 18, 19)

* * *

One very important machining operation requiring urgent and immediate attention is that of Automotive Crankshaft journal regrinding. We have been attempting to obtain the service of first class operator for (2) two years without success.

* * *

(.16) Consider out of engine realm.

* * *

(.4, .7) A practice I strongly disagree with. Usually associated with an economical way of raising compr. for the moment, but not in the long run. Disadvantages: Water jackets not lining up, Rocker geom, inlet man not sealing, gas flow and swirl area diff. to .at pistons are designed for, tappet adjust., (especially non-adjustables).

* * *

For a skilled machinist to give his maximum, he must be trained in importance on such items as componentry matching and sundry * e.g., carby's, distributors, cams, gear ratio. Otherwise he goes through life thinking that the only thing that makes horsepower is correct machining. Machining is only the base!

* * *

(17) Due to the complexity of today's piston, it is practically impossible to machine the cam and clearance required by today's standards.

* * * .

Advance education for precision machining of components? As all auto. machining is a high precision skill, therefore shouldn't it be the standard requirements of all training i.e., tolerances of .0001" piston pins.

* * *

I believe that axle/transmission components should be looked after by the experts in that field. In my shop we do work on these components as we have a fully equipped machine shop.

* * *

SPECIFIC COURSE INFORMATION - Continued...

3. The following topics are needed in the area of ENGINE TESTING AND EVALUATION.

COMMENTS:

Diagnosis of engine faults should be checked and double checked in the case of machine failure or faults.

* * *

To teach subjects as above to person who do not have a sound education in the basic principles of engine reconditioning, would be similar to trying to teach someone to waterski when they cannot swim and do not have a life jacket.

* * *

Gas flowing cylinder heads involves to much more than simply maximising the volume of air which can be passed through a port. This aspect of engine designs is the subject of intense debate between very highly qualified university graduates. Do we know the answers ourselves? If not, what do you propose to teach?

* * *

Dyno work is exciting and fulfilling and teaches frc trial and error the correct way to do work properly.

* * *

Please include cylinder leakage testing, valve seat run out and resultant seal testing of valves.

* * *

Full competence of dyno & carburettor reconditioning and modifications.

* * *

Swirl chamber and flame fronts extremely important.

* * *

Emphasis to be placed on correct component matching to result in correct applications e.g., heads, cams, induction, exhaust. Importance of distributors, induction etc...

4. The following topics are needed in the area of PRECISION MACHINING OF COMPONENTS.

COMMENTS:

It takes a special sort of person to be any good with modifies engines. A general course may improve the standard of same students, however, I find it extremely difficult to find anyone suitable to train. You have not stated whether the course is to be post-apprenticeship or part of training during apprenticeship.

* * *

All modifications to be made with more than sufficient strength of materials used.

* * *

* Same comments as for previous area, however, the principles of individual pipes are relatively easy to calculate and refine by experiment and we have to start somewhere. Disagree Topics - Feel these should be left ot skilled and PRACTICING welders.

* * *

We have found the level of skill required seriously lacking in general mechanical apprenticeships for our application. Thus we have chosen Fitters with some racing background or experience and then taught them our own specific requirements. Your proposed course outlined above appears to give an excellent coverage. If we can be of further assistance, please don't hesitate to call.

* * *

Depending on numbers, or industry demand.

* * *

(.3) Accurate measurements and machining are required for suspension components and any cast iron suspension parts that are heated and/or bent should be thoroughly crack tested.

* * *

All above help in base understanding, cylinder heads - extreme specialist work, but badly lacking skilled tradesmen.

* * *

If these areas were welded and machined outside manufacturers specifications, we lose all insurance and end up in a small claims tribunal being fully responsible. Have spoken to Geoff Shepherd of the Consumer Affairs Department.

* * *

Suspension, chassis & safety components require extreme caution in design and manufacture. They require aviation industry skills and quality control - FAILURES CAN BE FATAL!!!

* * *

Teaching electric cast iron welding (without hard spots).

* * *